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Indigenous Polymer Coated Tin Free Steel Cans for Thermal Processing of Fish and Fish Products

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ABSTRACT

Polymer coated tin free steel (TFS) cans are being manufactured recently in India. This study was undertaken to evaluate the suitability of these cans for the thermal processing of various fish products. The polymer coating that substitutes the lacquer of conventional tin and aluminium cans was found to be suitable for food contact application. The double seam was examined manually as well as using a double seam analyzer. It was observed that the seal integrity was very good with an overlap of 62%. The cans withstood high temperature and pressure and they do not require over pressure during thermal processing. Sulphur staining was not noticed. Many varieties of fish products were processed in these cans and they were found to be acceptable even after one year of storage at ambient temperature.

Key words: Canning, Indigenous polymer coated tin-free steel cans, PET coating, Easy open ends.

INTRODUCTION

Canning is one of the earliest methods of food preservation. Ever since it's invention by Nicholas Appert, canning has undergone tremendous changes with respect to processes, machinery, type of containers etc. Notable among these are the developments occurred in the field of packaging materials for thermally processed foods in that it has advanced from its basic role of protecting the food to that of a salesman. Canned foods were traditionally packed tin cans. The tin resources of the world are limited to certain regions of the world and hence most of the countries including India have to import tin for which they are spending a huge amount of foreign exchange. Consequently these containers are very expensive, the container price along with packing charge accounting for about 30% of the total production. Added to it the cost of labor, cartons and other items shoots the cost up to 50% of the total production cost, making it unaffordable to the average Indian consumers and not competitive in most of the overseas markets. This is one of the main reasons for the collapse of Indian fish canning industry. In addition to these, tin containers also present problems like heavy rusting, development of metallic taste in the product upon storage, lacquer imperfection etc.

The lacquer paint contains Bisphenol, which is found to be an endocrine disrupter. Owing to these factors, attempts have been made worldwide to find a suitable alternative for tin cans. One of the major outcomes in this direction is the indigenous polymer coated tin free steel (TFS) cans. TFS also has the same steel substrate as of tin cans. Chromium coated steel plate is manufactured by electroplating cold rolled steel plates with chromic acid. The tin plate is provided with a protective coating of chromium metal and chromium oxide, 75% of the coating material consists of chromium metal adjacent to steel substrate and 25%chromium oxide above it. The appearance of the sheet is bright or semi bright compared to tin plates. TFS can also be made with nickel coating instead of chromium. As reported by Anon ( ), the various TFS materials differ mainly with respect to surface treatments applied to the steel and the resulting difference in corrosion resistance, appearance and enamel adhesion. Commercial developments of chrome plated and chrome treated steels for food cans began in Japan and materials of this type are now being manufactured in Japan, Europe, Britain etc. best examples of these materials are 'Can super' of Fuji iron and steel co. ltd, 'Hi -Top' of Toyo Kohan, Stainless weirchrome TFS-210' by US steel corp. etc.

Naresh *et al.,* described chromium coated steel plates as an alternative to tin-plates for canning food products.They also compared the economics of TFS with that of aluminium and tin cans. TFS cans with enameled interiors cans be used for many products like meat, vegetable products etc. where cathodic protection usually supplied by tin is not required (Naresh *et al.,*). Hottenroth (1973) investigated the behaviour of electrolytically chromated steel cans (Ancrolyt cans) towards certain organic acids of different pH in storage tests lasting for 3 months. In Poland, suitability of TFS cans for canning various fish products was investigated and compared with anodized aluminium and electrolytic tin plate cans. It was found that TFS cans were suitable for canning various fish products stored up to 24 months of storage (Pielichowska, and Chrzanowski, Barbeiri *et al.,* (1970) studied the suitability of various types of chromium coated steel compared against tinned steel for packaging food products. They found that chromium coated steel plates (0.1 m) were compatible to E 2.8/2.8 type tinned steel (0.38 m) in resistance to atmospheric corrosion and salt spray . The suitability of TFS for packing various products like fruits, vegetables, milk powder etc. has been described by many workers (Mc Farlane (1970) and Srinivasa gopal *et al.,* (1977). Mathews *et al.,* conducted a comparative study of groundnut oil packed in TFS and tin plate containers. They found no significant difference in P.V, FFA value and quality of oil between the two containers. The possibility of introducing TFS cans for canning of sulphur containing vegetables and fish products was described by Mahadeviah.

MATERIALS AND METHODS

Indigenous polymer coated TFS cans

Indegenous Polymer coated TFS cans of 307 X 109 size (6 oz capacity) manufactured by M/S Amtech packs, Mysore were used for the study. The can is made of ECCS plate with clear PET coating on either sides. The PET coating that substitutes the lacquer of conventional tin and aluminium cans has excellent chemical resistance, stable over a wide ranges of temperature (-60° - 220°C), machinable and has high content releasing property. The finished

plate has a thickness of 0.19mm (0.15 mm of base steel + 20 PET coating on either sides). The cans are made out of the steel plate by DRD process. The chromium coating along with the PET coating provides the can with a smooth, greyish, glistening appearance in addition to act as a barrier between the product and the base steel. The bottom of the can is designed for better stackability so that it can be stacked vertically without risk of toppling on the shelf. This also helps to reduce the storage space requirement for the cans.

The material is the same as for cans with a thickness of 0.28 mm (including PET coating on either sides). The edges of the lid are provided with a Neoprene rubber-sealing compound that forms a hermetic seal with body wall when double seamed. The lids are provided with scoring in circular form towards the periphery on the public side, which facilitate easy and complete opening of the can by just pulling the tab. The tab is attached to the lid by means of a rivet that prevents any possible leakage through the Lid- Rivet joint. A unique feature of the EOE is the Triple Fold Technology that helps to avoid the potential injury to fingers on opening the can and the use of can openers. This is particularly advantageous over the conventional tin cans where the cut surface always acts as a source of injury.

Physical Properties

The cans were subjected to various physical and chemical analysis following standard methods to determine its suitability for thermal processing and storage of various fish and fish products. Test for seam integrity was done as per the method described by Lin et al., 1984. The seam integrity parameters were also analyzed by using semi-automatic Double seam analyzer ("Quality By Vision", Model SEAMetal 9000M, Israel). For this double seamed cans were selected at random and three cut sections were made on the double seam one after the other using the twin blades of the seam saw which are rotating at a speed of about 500 rpm. The cut width is 12.9 mm, which accurately fits to the camera of seam analyser. The double seam parameters such as Seam length (L), Seam thickness (T), Body hook (BH), Cover hook (CH), Body thickness (tb), End plate thickness (tc) etc were measured using the seam analyzer SEAMetal 9000M.

For the purpose of determining the pressure holding capacity of the cans and to check for any leakage through the double seam, the cans were subjected to air pressure test. The cans were pierced with a piercing type of pressure gauge and then air was pumped inside using a foot operated pump until any distortion of the can or any leakage through the double seam area was noticed.. The double seamed cans have to be immersed in boiling water for 5 min prior to the test. The cans were also processed at different temperatures and pressures of 115°C (10lbs), 121.1°C (15lbs) and 126 °C (20lbs) in a pilot scale retort of model 24 rotary retorting systems (John Fraser and sons Ltd, UK. Model.No.5682) to determine it's ability to withstand different processing conditions. The vacuum inside the processed cans was determined by using a vacuum gauge of piercing type. Indigenous polymer coated TFS cans are provided with PET coating that comes in direct contact with the food that is processed and packed inside. Hence it should be checked for its suitability for food contact applications. The tests for food contact applications were done as per the method of FDA. The water holding capacity of the cans were determined.

The coating perfection of the PET coating were analyzed using the Lacquer Coating Breakage (LCB)

Detector and the percent perfection of indigenous cans were compared with the imported TFS cans and aluminium cans. The EOE was tested for leakage especially at the scoring area. The lids were kept in between 2 cups, the upper one of which is fitted with sensors. From the bottom, air pressure at 25 psi is applied. Any air leaking through the lid and reaching the other side is detected by the sensors. The cans were tested for their resistance to sulphide blackening employing sulphur black point test. The polymeric coating of TFS cans was subjected to delamination test using various organic solvents like acetone, carbon tetra chloride, chloroform, diethyl ether, ethyl acetate, n-heptane, methanol, and petroleum ether. Panels of 1 X 1 cm size were taken and immersed in organic solvents. They were taken out after 24 hrs and examined for any delamination of the PET coating. When there was no peeling they were kept immersed for another 12 hrs. The panels were taken out and heated in water bath for few minutes and examined for delamination of the coating.

THERMAL PROCESSING OF FISH AND FISH PRODUCTS

Several fish and fish products like sardine in Brine, sardine in Oil, sardine in Curry, Mackerel in Brine, Mackerel in Oil, Mackerel in Curry, Tuna in Brine, Tuna in Oil, Tuna in Curry, Prawn Manchurian, Muglai U.P Curry, Punjab Fish Curry, Seer Fish Moilee etc were processed to different F0 values in TFS cans and were subjected to storage study with respect to sensory parameters. Processed cans were opened periodically and analyzed for discoloration, internal rusting, peeling of PET coating and adhesion of materials to the can interior.

RESULTS AND DISCUSSION

Physical Properties

The various physical properties of indigenous polymer-coated T.F.S cans were studied and the results are presented in Table-1. The results of test for seam integrity using double seam analyses are given in **Fig-1**. The overlap was 63%, which is well above the requirement. Integrity of the can seam is one of the important factor contributing to the bacteriological safety of canned foods. The air pressure test showed that the cans are capable of withstanding internal pressure up to 25 psig. Leakage through the seams occurred at 40 psi. Fish and fishery products are usually processed at 121.10 C with a corresponding pressure of 15 psig. When processed under different temperatures of 115 0 C (10 lbs), 121.1 0C (15 lbs) and 126 0 C (20lbs) the cans were found to retain their original shape without undergoing any distortion, and they do not require any overpressure during processing. The results of food contact application were also within the limits. Water holding capacity is an important factor of commercial importance in case of products like Tuna in oil, Mackerel in oil etc in which the drained weight is fixed on the basis of the water holding capacity of the can (usually 67-70% of the water holding capacity). Thus the packer has to adjust the filling weight in such a way that the customer gets a drained weight of 67-70% of the water holding capacity. The 307 X 109 size TFS cans have a water holding capacity of 180 ml. The coating perfection of indigenous polymer coated TFS cans were

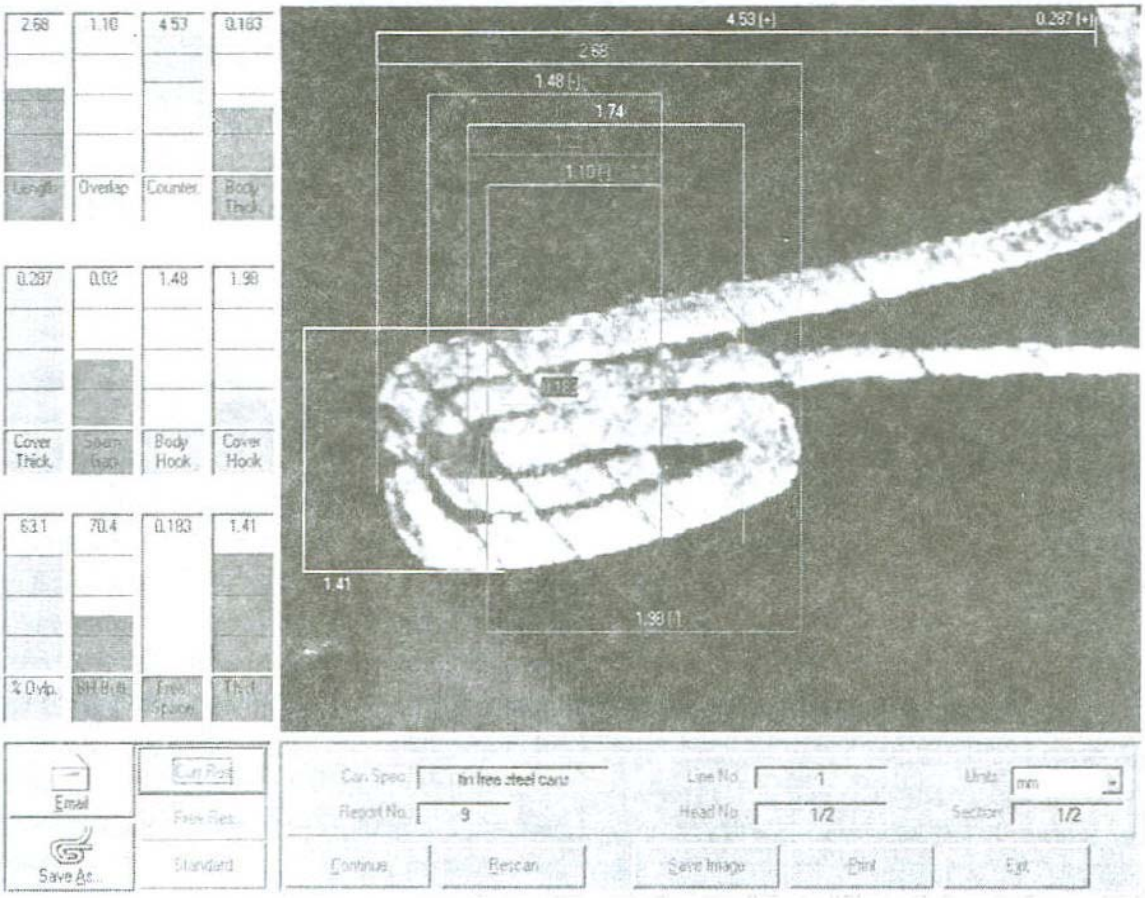

Fig-1.Double seam parameters of indigenous polymer coated tin free steel cans (Quality By Vision, model *SEAMetal 9000M, Israel).*

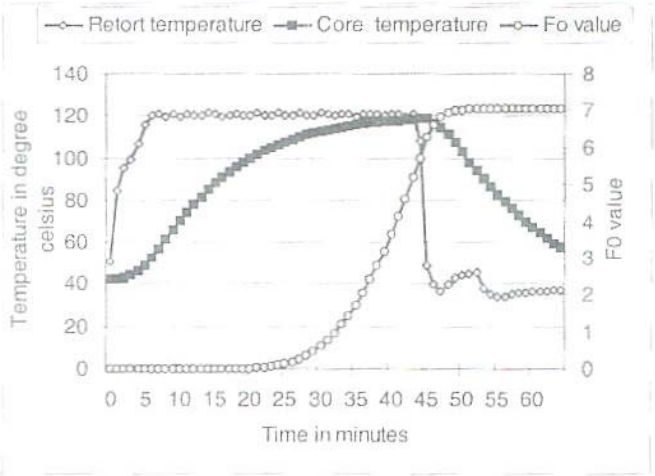

Fig-2 Heat penetration curve with respect to F_0 value of fish product processed in indegenous polymer coated TFS can

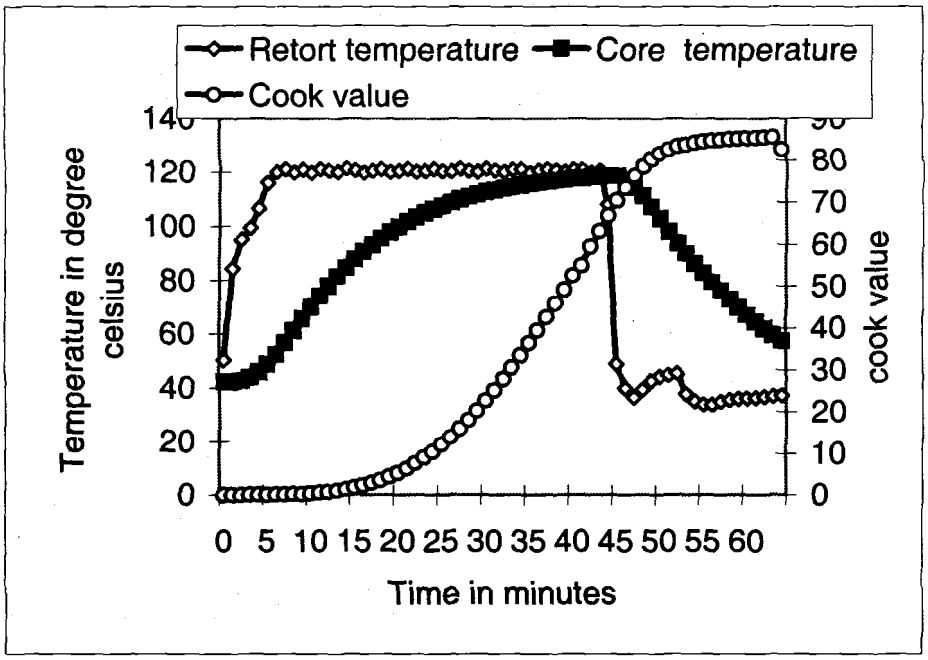

Fig-3 Heat penetration curve with respect to cook value of fish product processed in indegenous polymer coated TFS can

Table 1. Physical properties of indigenous TFS cans

Result	Parameter*
1.Air pressure test	Withstands up to 25 psig
2.Test for food contact application	
a) Water soluble extractives	6.9±0. 003 mg/litre
b) n-heptane soluble extractives	25 ±0. 002mg/litre
3. % Overlap	63 ±0.03 %
4. Body plate thickness	0.18±0. 001 mm
5. Endplate thickness	0.28±0. 002 mm
6. Water holding capacity	180 ml
7. Sulphur staining test	No blackening
8. Determination of vacuum	100 mm Hg

Table 2.Results of comparative analysis for coating perfection

Type of container	%coating perfection
Imported TFS cans	60± 0 .5
Indigenous TFS cans	100 0.5
Aluminum cans	20 0.5

tested and compared with that of imported TFS cans and Aluminium cans and the results are given in **Table-2.** It was found that the indigenous TFS cans maintained 100±0.5% coating perfection where as the imported TFS cans recorded a success rate of 60±0.5% and for Aluminium cans, it was 20±0.5% only. Upon leakage test, the indigenous EOE gave satisfactory results. The sulphur black point test showed that the indigenous TFS cans are resistant to sulphide blackening ad can be used for thermal processing of sulphur containing foods like fish, meat etc. The delamination test conducted with various organic solvents with immersion period of 36 hrs showed no signs of delamination. Thus it is evident that the PET coating is firmly attached to the base plate. These results indicate that the indigenous polymer coated easy open-end T.F.S cans are suitable for the thermal processing offish and fish products.

Thermal Processing and Storage Of Fish and Fish Products

Upon thermal processing to the required F0 values and storage, various fish and fish products were found to be acceptable in terms of sensory attributes even after 1 year. A typical heat penetration curve with respect to F0 value and cook value of fish product processed in Indigenous TFS cans is given in **Fig- 2 & 3.** Periodic analysis of the processed cans showed no signs of internal rusting, discoloration, peeling of PET coating and were found to have good content releasing property without any adhesion of the fish pieces to the inner wall of the can.

Conclusion

The study of the physical properties of indigenously manufactured polymer coated tin free steel cans showed that they are suitable for the thermal processing of fish and fish products. Upon storage study various fish and fish products were found to be acceptable even after 1 year at ambient temperature (28-310C). These cans are having the added advantages of better appearance, cheaper price, easy open ends, triple food technology etc. that makes it an ideal alternative for the conventional tin and aluminium cans. It is expected that these cans can revive the already collapsed canning industry in India

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